津波が引き起こす電磁場の非一様薄層導体近似を用いた順問題解

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Forward solution of the electromagnetic field induced by tsunamis using non-uniform thin-sheet approximation

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A seafloor geomagnetic observatory in the northwest Pacific detected clear electromagnetic (EM) variations associated with tsunami passage from two earthquakes that occurred along the Kuril Trench (Toh et al., 2011). Previous seismological analyses indicated that the M8.3 earthquake on 15 November 2006 was an underthrust type on the landward slope of the trench, while the M8.1 earthquake on 13 January 2007 was a normal fault type on the seaward side (Ammon et al., 2008). Here we report the simulation results on the frequency dependence of those tsunami-induced EM signals observed at the seafloor, using a three-dimensional (3-D) non-uniform thin-sheet approximation by Dawson and Weaver (1979) and McKirdy, Weaver, & Dawson (1985), which can accommodate not only the inducing non-uniform source fields caused by particle motions of conducting seawater at the time of tsunami passage but also the self-induction effect within the ocean and its conductive substrata.

Horizontal particle motions were calculated by Fujii and Satake (2008) with two types of hydrodynamic approximation, viz., the Boussinesq approximation and the long-wave approximation. Because the dispersion effect of each tsunami was more remarkable in the 2007 event, the observed EM variations were expected to be more compatible with the simulated EM signals using the Boussinesq approximation than the long-wave approximation. We calculated EM variations after we confirmed that synthetic plane waves in a flat ocean produced theoretically predicted harmonic EM variations well. In both approximations, the calculated EM variations associated with the initial wave of the tsunami at the time of the 2006 event are consistent with the observed ones, but the agreement became worse for the subsequent tsunami phases.

As for the 2007 event, the calculated EM variations were less consistent compared with the 2006 event irrespective to the hydrodynamic approximations used. This can be due to the current limitation of thin sheet approximation in our model. We could calculate EM variations only between 256s and 3840s, but the dominant frequency of tsunamis in the 2007 event was approximately 3mHz as described by Toh et al., 2008.

This can be interpreted as the reason of the disagreement between calculated and observed data in the 2007 event.

In this presentation, we will further discuss the advantages and disadvantages of the frequency-domain simulation for tsunami EM signals. Also, we will emphasize the importance of the EM observation on the seafloor for tsunami early warning in comparison with the conventional tsunami-height measurements and/or the geomagnetic observations on land.

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